International Journal of Computer Science
and Engineering (IJCSE)
ISSN(P): 2278-9960; ISSN(E): 2278-9979
Vol. 4, Issue 2, Mar 2015, 1-8

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

TRELLIS CODED MODULATION OVER LAND MOBILE SATELLITE CHANNEL

KHALID W. HAMEED

Al-Nahrain University Information Engineering College, Baghdad, Iraq

ABSTRACT

In order to start designing any communication system, simulation is needed and especially when the system design cost is very expensive like satellite link. The simulation make us take the right decision about the system and its component and parameters. One of to the trends enhance the transmission is the use of coding. In this paper the performance of trellis coding modulation (TCM) over land mobile satellite (LMS) channel is presented and compared with other coding method and the absent of coding. It was found that the supplement of coding will not enhance the system always and the TCM is not always give better performance over normal coding in all cases.

KEYWORDS: Trellis Coded Modulation over Land Mobile Satellite Communication Channel Using Loo's Model

INTRODUCTION

This paper is reported on the performance of two types of trellis coded modulation over land mobile satellite communication channel using Loo's model.

Satellite communication has found its place in practice and is implemented in numerous applications. Some of the more common implementations are Global Positioning Systems, satellite television and marine communications [1]. There is a renewed interest and market opportunities for Mobile Satellite Service (MSS) for it is an attractive approach in areas of world not well covered by existing terrestrial infrastructures [2]. For small, portable or even handheld terminals, the MSSs may suffer from time varying non Line-of-Sight (LOS) fading propagation conditions due to the presence of multipath[2].

A link budget analysis forms the cornerstone of the system design. Link budgets are performed in order to analyses the critical factors in the transmission chain and to optimize the performance characteristics, such as transmission power, bit rate and so on, in order to ensure that a given target quality of service can be achieved [3].

The possible solution to overcome the bad channel condition and decrease BER is to increase transmission power. We can increase the transmission power in terrestrial station but this solution is restricted with the power limitation in mobile units and the satellite itself. One of the key designs in communication systems is the bandwidth efficiency. So the use higher order modulation can make efficient use of bandwidth, but it will enfaces with increase of BER. To make efficient use of power and bandwidth of a system, adaptive scheme for modulation is used; it was discussed over satellite link in [2]. Another solution to enhance the link is the use trellis coded modulation proposed by Ungerboeck in [4]. [5] and [6] had discussed the TCM over satellite channel. But non of them use the QPSK nor use the LMS channel model (Loo's Model). Here in a description of simulation for the transmission over the satellite link depending on Loo's channel model using MATLAB is presented.

SYSTEM MODEL

The system model used in the simulation is shown in Figure 1. The core of the model is the transmission channel which presents the satellite link channel. At both ends of the channel there are the modulator at the input port and demodulator at output port.

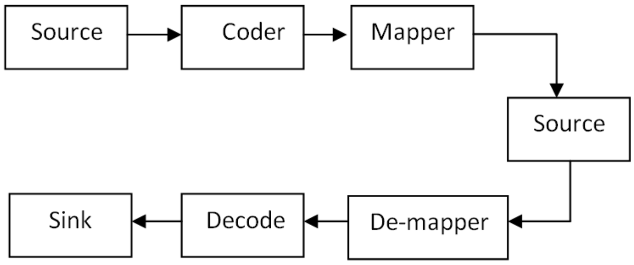

Figure 1

Here in the transmission system and channel used will be discussed.

- **Channels**

In this paper three types of channel are to be used in simulation, additive white gausian noise channel (AWGN), the Rayleigh fading channel and the Loo's channel model for land mobile satellite (LMS).

The first is generated by adding a random normal distributed variable with zero mean and the variance is depend on signal to noise ratio SNR and the modulation type as shown in table 1 below:

Table 1

No.	Modulation Level	σ_o
1	QPSK	0.5*10^(-SNR/10)
2	16QAM	1.25*10^(-SNR/10)
3	32QAM	2*10^(-SNR/10)
4	64QAM	3.4531*10^(-SNR/10)

The second channel is Rayleigh fading channel, which is characterized by:

$$f_R(r) = \frac{r}{\sigma^2} e^{-\left(\frac{r^2}{2\sigma^2}\right)}, r \geq 0$$

And can be generated according to the following equation from two random variables X_1 and X_2.

$$R = \sqrt{X^2 + Y^2, r \geq 0}$$

Where X, Y ~ $N(0,\sigma^2)$.

This will represent the attenuation of the path (α) which illustrated in Figure 3. The system will assume optimal equalizer ($1/\alpha$).

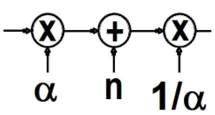

Figure 2

The Loo's model [Hoffman]: for LMS is described by

$$r.\exp(j\emptyset) = z.\exp(j\emptyset_o) + w.exp(j\emptyset)$$

with z lognormally distributed, w Rayleigh distributed and Φ and Φ_0 uniformly distributed between 0 and 2π. The probability density function (pdf) for r is:

$$p(r) = r/b_0\sqrt{2\pi d_0}\int_0^{\infty} 1/z\exp[-(\ln z-\mu)^2/2d_0-(r^2+z^2)/2b_0]I_0(rz/b_0)dz$$

with μ_o and $\sqrt{d_o}$ the mean and standard deviation of the lognormal pdf, b_0 the average scattered power due to the multipath and I_0 the Bessel function of zero'th order.

The lognormal component z could be generated using the following equation from a normal distributed r.v. as shown :

$$z = 10^{y/10}$$

Where y~ N $(0,\sigma^2)$.

- **The Scenarios**

Two scenarios are discussed in this paper. The first is the modulation without coding; the second one includes coding while the third one is using trellis coded modulation technique proposed by

The first scenario considered is to transmit the input stream of bit directly. The input bits stream is divided into two sets, one bit for I component and the next for the Q component and so forth for QPSK modulation. While for the 16QAM modulation, the set is consist of two bits instead of one bit. These bits assign the amplitude of the related component.

The second and third scenarios include a coder with their structure, rate 1/2 coder- figure 3 - is used to transform the single bit to two bits be transmitted using QPSK, while rate 3/4 coder – figure 4 - is used to make three bits suitable to be transmitted via 16QAM (i.e. 4 bits), where each two bits are assigned to a component.

The second is with convolution coder and gray mapping. The decoding method is Viterbi algorithm with hard decision. (i.e. the decoding depend on hamming distance of the received symbol). The third scenario is like the second in general but with two differences. The constellation distribution is according to [4] and the decoding method is soft decoding.

The mapping method is deferent between the normal transmission and TCM. The difference can be seen in figure 5, figure 6 and figure 7.

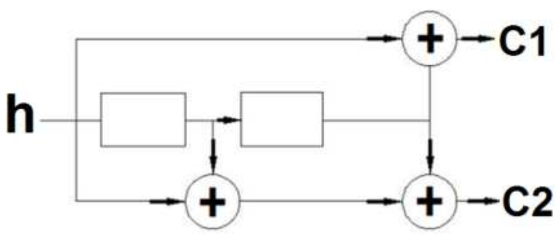

Figure 3: Rate 1/2 Coder

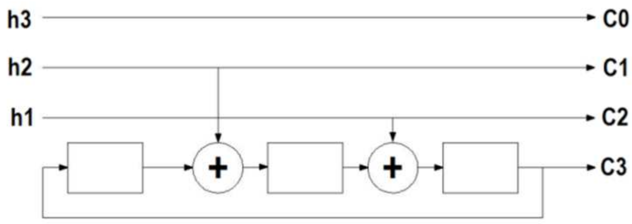

Figure 4: Rate 3/4 Coder

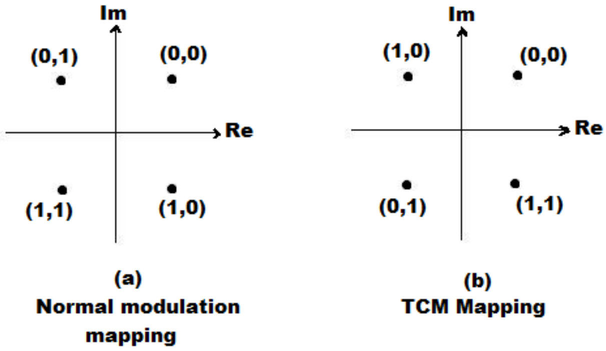

Figure 5: Constellation Mapping for QPSK Transmission

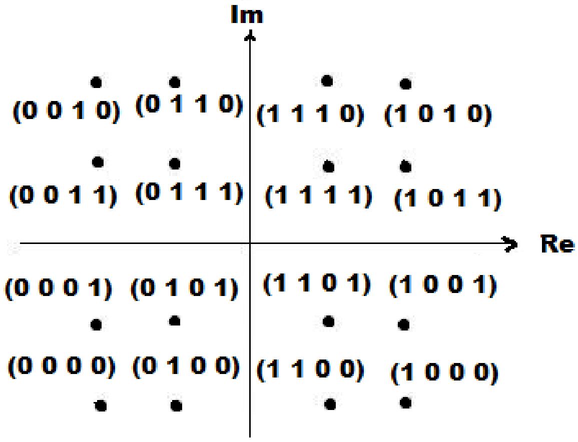

Figure 6: Mapping for 16QAM

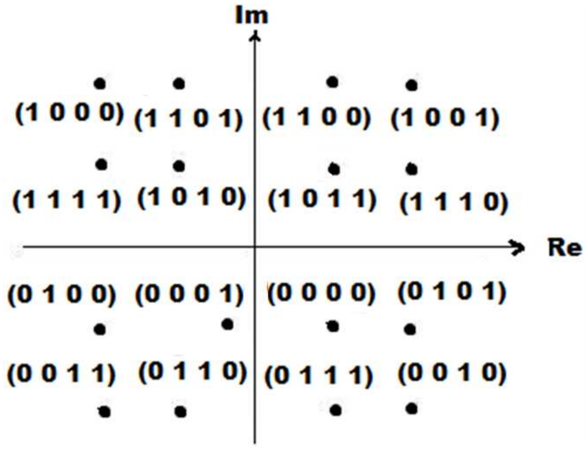

Figure 7: Mapping for 16QAM TCM

RESULTS

In this section the numerical results for the three scenarios of data transmission over various channels described in previous section are presented.

These results are obtained by simulate the system scenarios discussed before. Simulation is done by converting the system stages into algorithms and mathematical equations. The combination of these algorithms and equations describe the system behavior under various conditions and different parameters. The total bits used in each simulation were at minimum equals to 92e3 bit/ simulation. Sometimes this number was increased to 150e3 or up to 200e3 bits/simulation.

The results are shown in figure 8 to figure 14.

The figures 8, 9 and 10 represent the performance of QPSK, 16QAM and 64QAM modulation transmission over the channels considered in this paper.

Figure 11 shows the performance of QPSK over the three channels in a single plot. Figure 12 gathers the performance of all transmission methods (scenarios) over AWGN in single figure. Figure 13 gathers the performance of all transmission methods (scenarios) over Rayleigh channel in single figure. Figure 14 gathers the performance of all transmission methods (scenarios) over Loo's model in single figure.

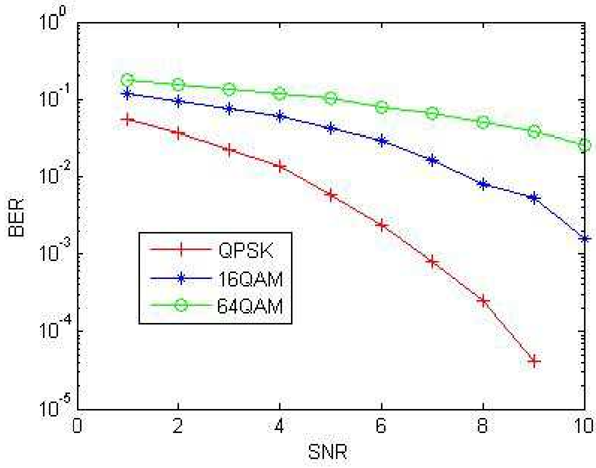

Figure 8: Comparison of Modulation Order over AWGN Channel

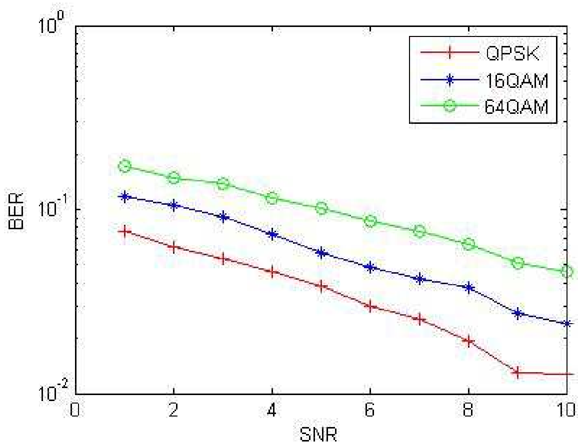

Figure 9: Comparison of Modulation Order over Rayleigh Fading Channel

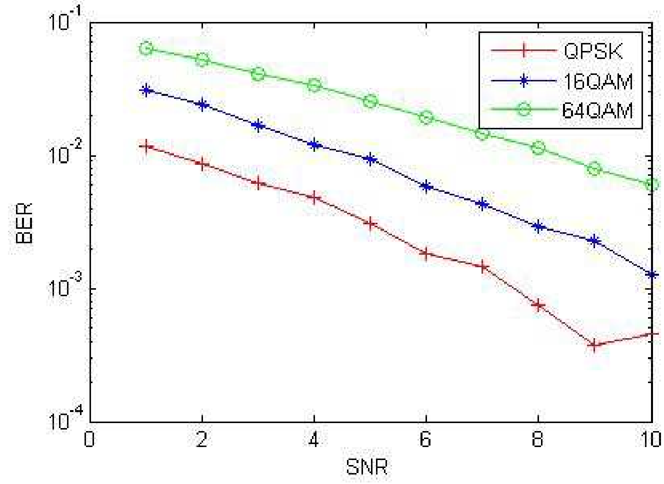

Figure 10: Comparison of Modulation Order over Loo's Channel Model

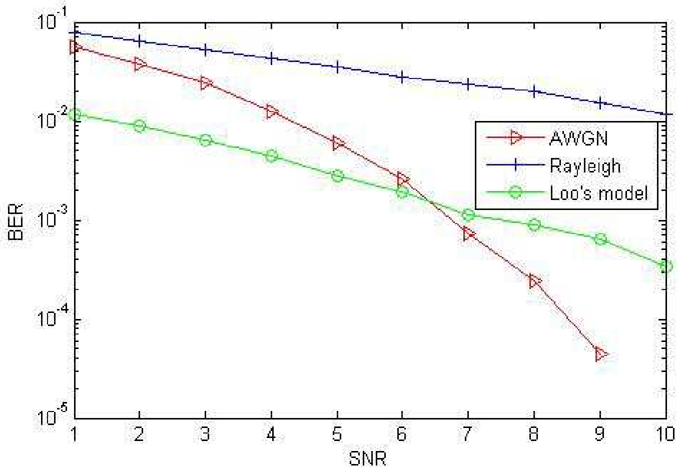

Figure 11: QPSK over Various Channels

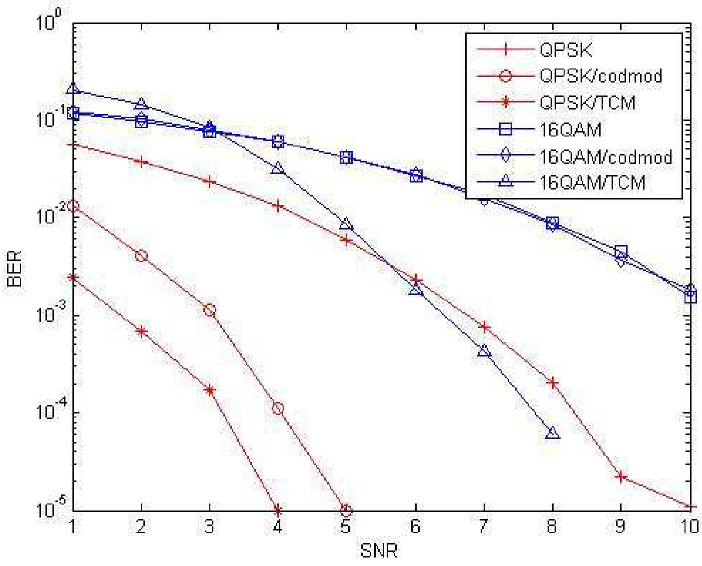

Figure 12: Performance of Various Transmissions over AWGN Channel Model

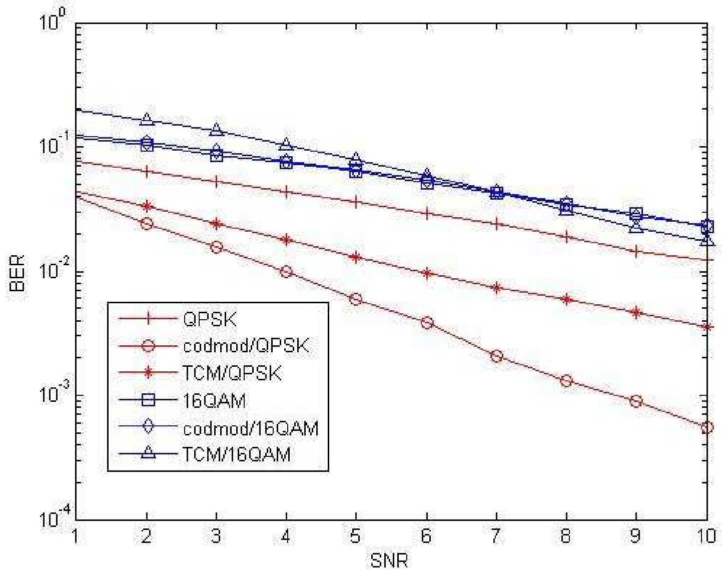

Figure 13: Performance of Various Transmissions over Rayleigh Fading Channel

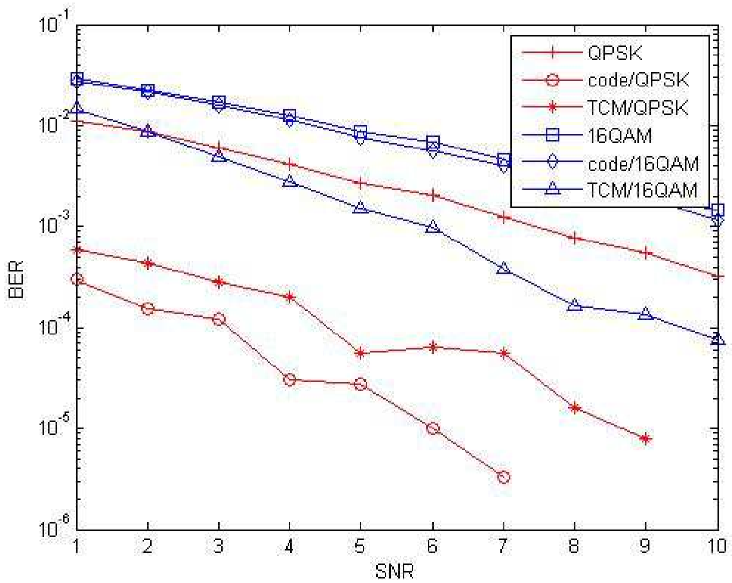

Figure 14: Performance of Various Transmissions over Loo's Channel Model

CONCLUSIONS

In this paper simulation was made to compare between different transmission methods. The methods are not in the same of complexity level. The expected results are the more complex system the better performance, but this was not exactly what was found by simulation. For QPSK this was true for AWGN channel, but in Rayleigh and Loo's channel the coding with gray mapping VIterbi decoding according to Hamming distance performs better results than TCM. On the other hand 16QAM show unusual results, where the more complex system (addition of coding) has no effect on the performance. But the TCM unlike QPSK give us the better performance always for Rayleigh and Loo's model and for more than 3db SNR in the AWGN channel.

REFERENCES

1. Gertjie S. Hoffmann et. al., A Brief Survey of Channel Models for Land Mobile Satellite Communication, http://www.techrepublic.com/resource-library/whitepapers/a-brief-survey-of-channel-models-for-land-mobile-satellite-communication/, sited on 3/12/2014.
2. Jinxiu Chen et al. Performance Evaluation of Adaptive Modulation System over Mobile Satellite Channels, JOURNAL OF NETWORKS, VOL. 8, NO. 6, JUNE 2013
3. Ray E. Sheriff, Y. Fun Hu, Mobile Satellite Communication Networks, John Wiley and Sons, 2001.
4. G. Ungerboeck, Trellis coded modulation with redundant signal sets, Part I: Introduction, IEEE Comm. Mag., 25(2):5–11, February 1987.
5. Riccardo De Gaudenzi et al. Performance Analysis of Turbo-Coded APSK Modulations over Nonlinear Satellite Channels. IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 5, NO. 9, SEPTEMBER 2006
6. Chinthananda Tellambura et al. Performance of Trellis Coded Modulation Schemes on Shadowed Mobile Satellite Communication Channels, lEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 43, NO. I, FEBRUARY 1994.